

# Identification of neonatal near miss by systematic screening for metabolic acidosis at birth

A. BONNAERENS<sup>1</sup>, A. THAENS<sup>1</sup>, T. MESENS<sup>1</sup>, C. VAN HOLSBEKE<sup>1</sup>, E. T. M. DE JONGE<sup>1</sup>, W. GYSELAERS<sup>1,2</sup>

<sup>1</sup>*Dept Obstetrics and Gynaecology, Ziekenhuis Oost Limburg, Genk, Belgium.*

<sup>2</sup>*Dept of Physiology, Hasselt University, Diepenbeek, Belgium.*

Correspondence at: Bonnaerens Ann, Department of Obstetrics and Gynaecology, Ziekenhuis Oost Limburg, Campus St Jan, Schiepse Bos 6, B-3600 Genk, Belgium.

E-mail: ann.bonnaerens@gmail.com

## Abstract

**Aims:** To evaluate the relevance of systematic screening for neonatal metabolic acidosis at birth as part of perinatal audit.

**Methods:** For every baby, born in Ziekenhuis Oost Limburg, Genk Belgium between 1/1/2010 and 31/12/2010, cord blood was analysed to diagnose metabolic acidosis, defined as arterial or venous pH  $\leq$  7.05 or 7.17 respectively, in association with base excess of  $\leq$  -10 mmol/L. Three observers identified indicators for suboptimal peripartur care with likely contribution to metabolic acidosis. In a multidisciplinary consensus meeting, these indicators were classified into 5 categories : (a) fetal monitoring error (b) labour management error, (c) instrumental vaginal delivery for fetal distress within 2 h of second stage, (d) non-obstetric medical complications, (e) preterm births or accidental cases at term.

**Results:** In a total of 2117 neonates, there were 11 intra-uterine, 1 intrapartum and 3 early neonatal deaths, bringing early perinatal mortality rate at 7.1‰. Metabolic acidosis was identified in 23 (1.1‰) babies, of which 21 (91.3%) left hospital in good clinical condition. Two babies (0.9‰), born in category c, had chronic neurologic symptoms.

**Discussion:** Systematic screening for neonatal metabolic acidosis caused a 2.5-fold increase of case identifications eligible for perinatal audit and opened perspectives towards rationalised improvement of perinatal care, in addition to the information obtained from cases of perinatal mortality. Next to indicators of perinatal mortality, perinatal audit programs should include neonatal metabolic acidosis as an extra parameter for quality assessment of perinatal care.

**Conclusion:** Adding cases of near-miss neonatal morbidity to perinatal mortalities in perinatal audit programs increases opportunities for improvement of perinatal care.

**Key words:** Birth asphyxia, metabolic acidosis, neonatal care, perinatal outcome, perinatal audit.

## Introduction

Measurement of umbilical cord pH is an objective measure for perinatal morbidity at birth and can be used for audit on prenatal care and management of labour (Vandenbussche *et al.*, 1999). Umbilical artery pH  $<$  7.05 is a marker for neonatal acidosis and is associated with an increased risk for neonatal complications, as compared to normal cord blood pH. Respiratory acidosis, associated with base-excess  $\geq$  10 mmol/L, is less severe than metabolic acidosis

with a deviating base-excess (Uzan *et al.*, 2003). The incidence of serious neonatal morbidity and post-asphyctic encephalopathy increases significantly with umbilical artery cord pH  $<$  7.00 (Gilstrap *et al.*, 1989; Goldaber *et al.*, 1991; Malin *et al.*, 2010). In the criteria for the diagnosis of intrapartum hypoxia related neonatal brain damage, a base excess of  $\leq$  -12 mmol/L is set as the cut-off value for definition of asphyxia (ACOG Committee Opinion, 2006; Andres *et al.*, 1999; Goodwin *et al.*, 1992; Low *et al.*, 1997; Sehdev *et al.*, 1997; Zupan, 2008).

As labour is the time span in which there is a substantial risk for asphyxia and asphyxia related mortality and morbidity, it is often questioned which particular aspects of labour management might enhance or prevent birth asphyxia. Some typical examples generally well known are uterine hyperactivity following administration of oxytocine, or hypotension related cardiotocographic fetal distress at installation of epidural anesthesia (Verspyck *et al.*, 2008). This study is a single center 1-year perinatal audit on the relevance of systematic screening for neonatal metabolic acidosis at birth with postnatal follow up of neonatal outcome, in order to identify preventable aspects of labour management which are associated with birth-related neonatal morbidity.

## Methods

### *Population and data collection*

At birth of each baby, born in ziekenhuis Oost Limburg Genk Belgium between 1/1/2010 and 31/12/2010, umbilical cord blood was sampled for blood gas analysis according to reported methodology (Sundström *et al.*, 2000). The Sundström criteria for metabolic acidosis are more stringent than the criteria for perinatal asphyxia, as defined by the American College of Obstetricians and Gynecologists (ACOG, 2006) and allow for identification of a higher number of index cases with potential suboptimal care. Both venous and arterial blood was collected. The samples were collected within minutes after birth and sent to the lab instantly for analysis.

### *Analysis*

All cases of metabolic acidosis were identified by blood gas analysis. Criteria for established metabolic acidosis were arterial pH < 7.05 or venous pH < 7.17, in association with base excess  $\leq$  -10 mmol/L. In cases of sampling- or analysis-error, neonates with persistently low Apgar score of  $\leq$  6 after 5 minutes were considered clinically at risk for metabolic acidosis (Sundström *et al.*, 2000; Uzan *et al.*, 2003; Zupan, 2008) and were also included for further analysis.

For all cases of neonatal metabolic acidosis or persistently low Apgar score, patient's labour ward notes, fetal monitoring traces and neonatologist's records were evaluated retrospectively by three independent observers for identification of indicators of suboptimal peripartal care. After this, all cases were discussed with a group of obstetricians and neonatologists of Ziekenhuis Oost Limburg Genk to obtain overall consent for classification into 1 of five categories: (a) failure to detect or misinterpretation

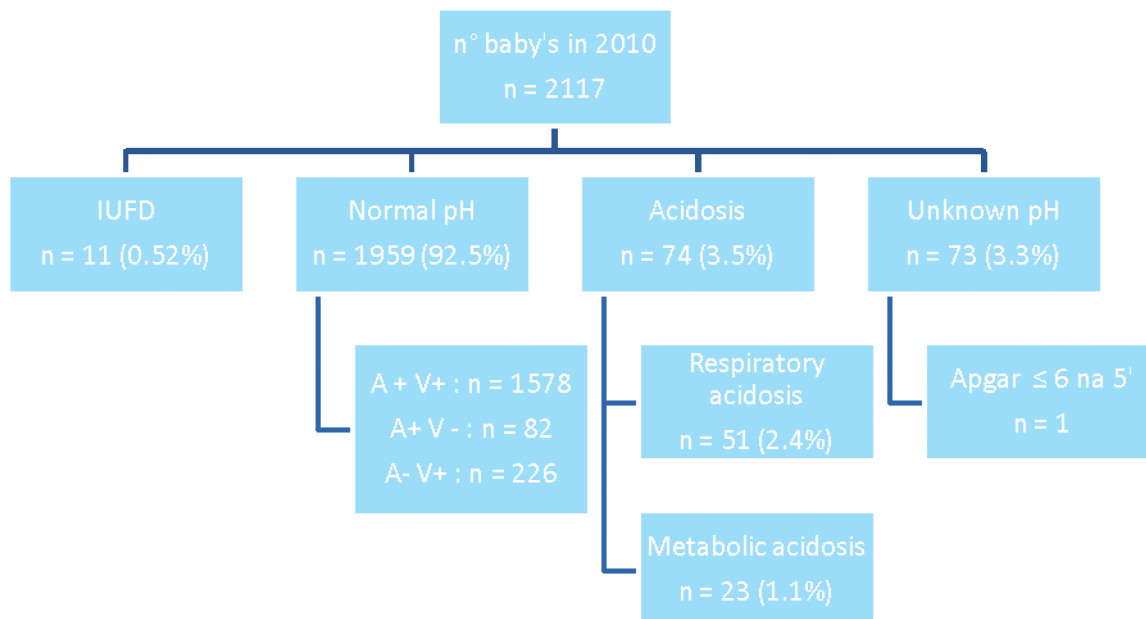
of signs of fetal distress was labelled as "non-conformity with guidelines for fetal monitoring" (Sundström *et al.*, 2000), (b) abstaining from or over-dosage of oxytocin for augmentation of uterine contractility was labeled as "non-conformity with the protocol for active management of labour" (Boylan *et al.*, 2004), (c) early second stage intervention with instrumental vaginal delivery for fetal distress within 2h after full dilatation, (d) complications from non-obstetric interventions, such as anesthesia, and (e) preterm births or accidental and unavoidable cases at term such as placental abruption, chorio-amnionitis,...

## Results

There was a total of 2056 deliveries with birth of 2117 babies. In this population, there were 11 cases of in utero fetal demise, 1 intrapartum death and 3 early neonatal deaths, bringing the total rate of early perinatal mortality to 7.1 per thousand births (15/2117).

As shown in Figure 1, 92.5% (1959/2117) of babies had normal pH values, whereas 3.5% (74/2117) were born with acidosis. Of these, 23 (1.1%) babies suffered metabolic acidosis and 51 (2.4%) had respiratory acidosis. There were 73 (3.3%) babies with unknown pH values, of which one showed a persistently low apgar score of  $\leq$  6 after 5 minutes.

Figure 2 shows the clinical classification of 23 babies with metabolic acidosis or persistently low Apgar score, excluding 1 intrapartum death following maternal incomppliance to labour support. For thirteen (54%) babies, no recognizable pattern of preventable measures during labour was identified, whereas ten others were classified as follows : 4 (16.7%) cases of violation of fetal monitoring guidelines, 1 (4.2%) case of violation of the protocol for active management of labour, 1 (4.2%) total spinal block after epidural anesthesia and 5 (20.8%) cases of instrumental vaginal delivery for fetal distress within 2 h of second stage. Apart from the premature births (n = 5), all babies left hospital within a week after birth, and 21 babies (91.3%) were in good clinical condition at discharge. Two babies (0.9% of the total population) showed persistence of neurologic symptoms for at least 6 months after birth and therefore were in long term neonatal follow up. Both babies were classified in the group of instrumental vaginal delivery for fetal distress within 2 h of second stage. One of these neonates had umbilical artery pH less than 7.0 with base-excess < -12 mmol/l and the other one had 5 minute Apgar score  $\leq$  6, for which both had criteria of perinatal asphyxia fulfilled.



**Fig. 1.** — Classification of baby's born in 2010 based on the arterial and venous pH taken at birth. A+ or A- indicate successful or failed arterial pH measurement respectively, V+ or V- indicate successful or failed venous pH measurement respectively.

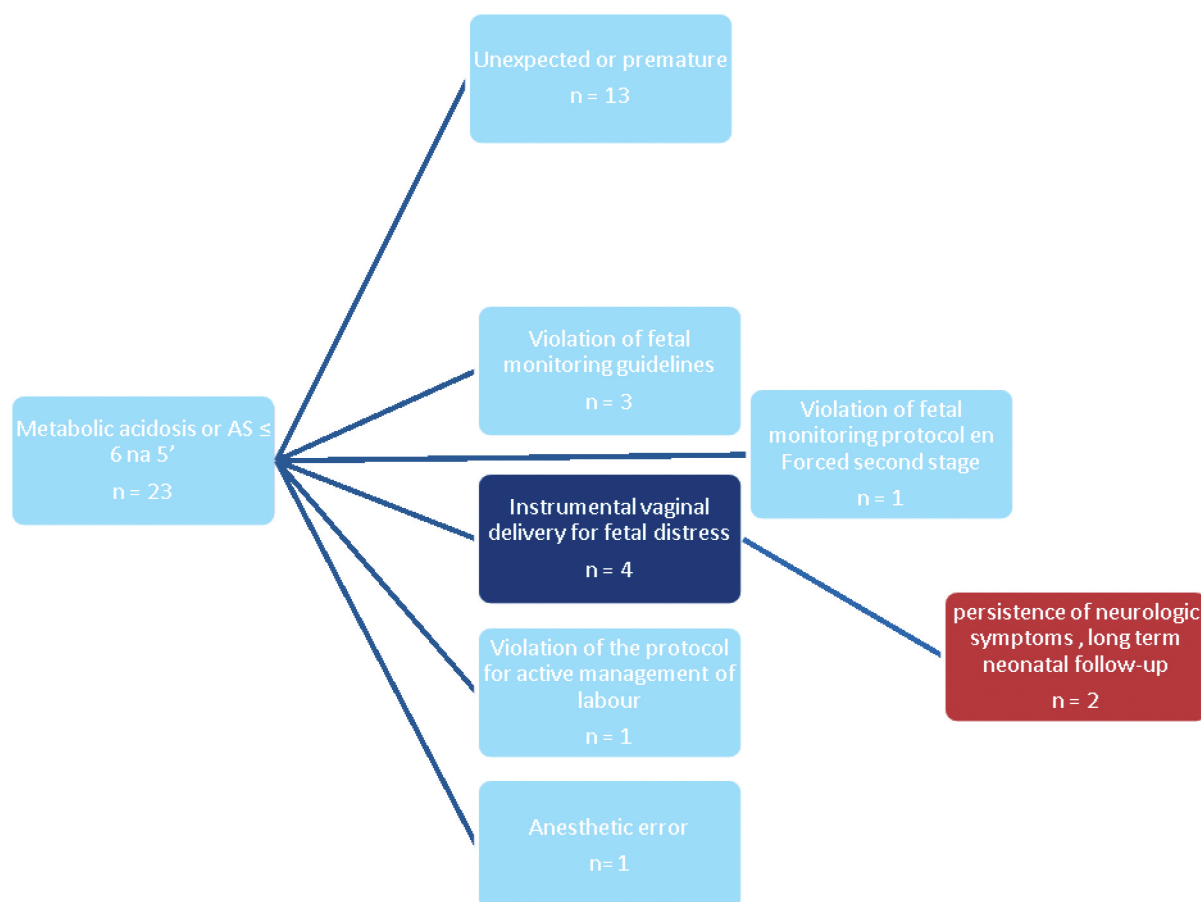
## Discussion

Reported incidence of neonatal metabolic acidosis and birth asphyxia depends on the definitions used. An umbilical artery pH < 7.05 combined with base-excess ≤ -10 mmol/L is recorded in approximately 2.5% of the population (Sundström *et al.*, 2000). Perinatal asphyxia with pH < 7.0 and base-excess ≤ -12 mmol/L is observed in approximately 0.5-1% of term deliveries (Richardson *et al.*, 2005; Wayenberg *et al.*, 1998; Zupan, 2008). Many other definitions and criteria are used today. In our study, neonatal metabolic acidosis and perinatal asphyxia was found in 1.1% (24/2105) and 0.9‰ (2/2105) of live births respectively.

Two babies born with metabolic acidosis showed signs of persistent neurologic symptoms after birth, and met criteria of birth asphyxia. Both babies were born with instrumental vaginal delivery for fetal distress within 2 h of second stage. Guidelines on management of second stage of labour show increased rates of spontaneous vaginal delivery in prolonged second stage with delayed pushing, as compared with early pushing at diagnosis of full dilatation, without associated differences in other parameters of maternal or neonatal outcome (Berghella, 2007; Roberts *et al.*, 2004). Fetal distress after full dilatation is often anticipated with assisted birth techniques, such as instrumental vaginal delivery (de Jonge, 1991). However, in case of insufficient descend or incomplete adaptation of the fetal head to the shape of the birth canal, cesarean section is to be preferred over difficult instrumental delivery,

specifically for an already compromised baby. Intra-uterine resuscitation in the early second stage of labour can be considered an alternative for immediate operative delivery, on the condition that fetal monitoring shows complete and reassuring recovery. Reports on intra-uterine resuscitation in the second stage are scarce. Obstetric interventions with successful effect on intra-uterine fetal recovery from distress include interruption of IV administration of oxytocin, acute tocolysis in case of uterine hypertonia, maternal repositioning and amnio-infusion for oligo-amnion (Verspyck *et al.*, 2008). Maternal oxygen administration is not recommended since it has been associated with lower cord blood pH values compared to controls (Fawole *et al.*, 2007). The use of betamimetics in the second stage has been linked to increased rate of forceps deliveries (Campbell *et al.*, 1978). Increased risk for postpartum hemorrhage and for urinary incontinence 3 months postpartum (Brown *et al.*, 2011) after prolonged second stage have also been reported. From the audit results presented in this paper, we have introduced in our local protocol for management of labour the consideration of intra-uterine resuscitation in the second stage of labour as an alternative to operative delivery for fetal distress, after discussing harms and benefits with the parents. Results of this adaptation of our protocol are to be assessed prospectively in forthcoming years.

Programs of perinatal audit usually include data on maternal mortality, near-miss maternal morbidity, stillbirths and neonatal mortality (Drife, 2006). In Belgium and other well-developed countries, low rates of < 1/10.000 for maternal mortality and < 1%



**Fig. 2.** — Clinical classification of 23 babies with metabolic acidosis or persistently low Apgar score, excluding 1 intrapartum death following maternal incomppliance to labour support.

for perinatal mortality are reported (Study Centre for Perinatal Epidemiology, Brussels). Even with low maternal and neonatal mortality rates, guidelines towards further improvement of perinatal care are reported (Flenady *et al.*, 2011), however, changing obstetric and perinatal management based on mortality rates only, without using figures on morbidity, may overlook those strategies causing a paradoxical shift from mortality to severe morbidity (Wilson *et al.*, 2007). Currently, registration of neonatal near-miss cases based on abnormal cord blood gas analysis, are usually not part of any audit program and no accepted definition of neonatal near-miss currently exists (Avenant, 2009). It has been shown that the neonatal near-miss approach provides data useful to evaluate and improve the quality of perinatal care (Pileggi *et al.*, 2010). Assessment of cord blood pH is enlisted in the RCOG recommendations towards improvement of patient safety (RCOG, 2009). Our study illustrates that the assessment of neonatal metabolic status at birth has been helpful to identify indicators of care with increased risk for persistent perinatal morbidity and to define strategies towards improvement of perinatal outcome. In our audit, by adding the cases of neonatal metabolic acidosis to those of perinatal mortality, the number of events

eligible for analysing quality of perinatal care increased from 15 to 38, or from 0.7% of all births to 1.8%, which reflects a 2.5 fold increase. The near-miss principle of perinatal audit thus adds cases to evaluate and optimize intrapartum care. From this, we recommend that programs of perinatal audit should include figures on perinatal morbidity next to those of perinatal mortality, maternal morbidity and maternal mortality.

We conclude from our data that systematic screening for neonatal metabolic acidosis at birth helps to identify indicators of prenatal and obstetric management with potentially increased risk for adverse outcome, in addition to those identified with audit of perinatal mortality. Therefore, we suggest that audit programs towards improvement of perinatal care should include data on perinatal near-miss morbidity, next to those on perinatal mortality, maternal morbidity and maternal mortality.

## References

- ACOG Committee Opinion No. 348, November 2006: Umbilical cord blood gas and acid-base analysis. Obstetrics and Gynecology, 2006
- Andres RL, Saade G, Gilstrap LC *et al.* Association between umbilical blood gas parameters and neonatal morbidity and

- death in neonates with pathologic fetal acidemia. *Am J Obstet Gynecol* 1999; 181: 867-71.
- Avenant T. Neonatal near miss: a measure of the quality of obstetric care. *Best Pract Res Clin Obstet Gynaecol*. 2009; 23: 369-74.
- Berghella V. Part I Normal pregnancy Chapter 7 Second stage of labor. In series *Maternal-Fetal Medicine. Obstetric Evidence-Based Guidelines*. Informa Healthcare, 2007; 58-60.
- Boylan P, O'Driscoll K, Meagher D. *Active Management of Labour*. Elsevier Health Sciences 2004.
- Brown S, Gartland D, Donath S *et al*. Effects of prolonged second stage, method of birth, timing of caesarean section and other obstetric risk factors on postnatal urinary incontinence: an Australian nulliparous cohort study. *BJOG*. 2011; 118: 991-1000.
- Campbell J, Anderson I, Chang A *et al*. The Use of Ritodrine in The Management of The Fetus During the Second Stage of Labour. *Australian and New Zealand Journal of Obstetrics and Gynaecology*. 1978; 18: 110-13.
- de Jonge ET. A properly conducted trial of ventouse can prevent unexpected failure of instrumental delivery. *S Afr Med J* 1991; 79: 445-6.
- Drife JO. Perinatal audit in low- and high-income countries. *Semin Fetal Neonatal Med*. 2006; 11: 29-36.
- Fawole B, Hofmeyr GJ. Maternal oxygen administration for fetal distress. *Cochrane Database Syst Rev*. 2003;(4): CD000136.
- Flenady V, Koopmans L, Middleton P *et al*. Major risk factors for stillbirth in high-income countries: a systematic review and meta-analysis. *Lancet*. 2011; 377(9774): 1331-40.
- Gilstrap LC, Leveno KJ, Burris J *et al*. Diagnosis of birth asphyxia on the basis of fetal pH, Apgar score, and newborn cerebral dysfunction. *Am J Obstet Gynecol* 1989; 161: 825-30.
- Goldaber KG, Gilstrap LC, Leveno KJ *et al*. Pathologic fetal acidemia. *Obstet Gynecol* 1991; 78: 1103-7.
- Goodwin TM, Belai I, Hernandez P *et al*. Asphyxial complications in the term newborn with severe umbilical acidemia. *Am J Obstet Gynecol* 1992; 167: 1506-12.
- Low JA, Lindsay BG, Derrick EJ. Threshold of metabolic acidosis associated with newborn complications. *Am J Obstet Gynecol* 1997; 177: 1391-4.
- Malin GL, Morris RK, Khan KS. Strength of association between umbilical cord pH and perinatal and long term outcomes: systematic review and meta-analysis. *BMJ*. 2010; 13; 340: c1471.
- Pileggi C, Souza JP, Cecatti JG *et al*. Neonatal near miss approach in the 2005 WHO Global Survey Brazil. *J Pediatr (Rio J)*. 2010; 86: 21-6.
- Richardson BS, Czikk MJ, daSilva O *et al*. The impact of labor at term on measures of neonatal outcome. *American Journal of Obstetrics & Gynecology* 2005; 192: 219-26.
- Roberts CL, Torvaldsen S, Cameron CA *et al*. Delayed versus early pushing in women with epidural analgesia: a systematic review and meta-analysis. *BJOG*. 2004; 111: 1333-40.
- Sehdev HM, Stamilio DM, Macones GA *et al*. Predictive factors for neonatal morbidity in neonates with an umbilical arterial cord pH less than 7.00. *Am J Obstet Gynecol* 1997; 177: 1030-4.
- Sundström AK, Rosén D, Rosén KG. *Foetale bewaking*. Neoventa 2000.
- Uzan S, Berkane N, Verstraete L *et al*. Acid base balance in the fetus during labor: pathophysiology and exploration methods. *J Gynecol Obstet Biol Reprod (Paris)*. 2003; 32: 1S68-78.
- Vandenbussche FP, Oepkes D, Keirse MJ. The merit of routine cord blood pH measurement at birth. *J Perinat Med* 1999; 27: 158-65.
- Verspyck E, Sentilhes L. Review: Abnormal fetal heart rate patterns associated with different labour managements and intrauterine resuscitation techniques. *J Gynecol Obstet Biol Reprod*. 2008; 37: S56-64.
- Wayenberg JL, Vermeylen D, Damis E. Definition of asphyxia neonatorum and incidence of neurologic and systemic complications in the full-term newborn. *Arch Pediatr*. 1998; 5(10): 1065-71.
- Wilson RE, Salihu HM. The paradox of obstetric "near misses": converting maternal mortality into morbidity. *Int J Fertil Womens Med*. 2007; 52: 121-7.
- Zupan SV. Definition of intrapartum asphyxia and effects on outcome. *J Gynecol Obstet Biol Reprod (Paris)*. 2008; 37: S7-15.